Protecting Stored Wheat Against Insects

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PROTECTING STORED WHEAT AGAINST INSECTS

By F. A. FENTON

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Following harvest, much wheat is stored in farm bins for varying lengths of time before it is taken to the local flour mill or grain elevator. This year (1941), because of lack of sufficient terminal storage space and possible shortage of freight cars, a much larger amount than usual will have to be held on the farm.

Stored wheat is subject to the attacks of a number of insects which begin their destructive work almost as soon as it is put into the bin. Unless proper precautions are taken, the infestation soon builds up to dangerous proportions; and finally the grain is utterly destroyed or made valueless.

Many different kinds of insects live in stored wheat, and their combined attacks will eventually reduce it to a pile of badly eaten, moldy grain, unfit for the market. Several species, such as the rice weevil and Angoumois grain moth, infest whole kernels. Other species will attack only cracked or broken seeds. At least one species lives on damp, moldy grain; and there are beneficial forms that prey on the injurious species. Aside from direct loss such as the destruction of the wheat, insects very often cause it to heat injuriously.

The purpose of this circular is to describe methods of fumigation and various other effective ways of preventing or controlling this insect infestation.

SOURCES OF BIN INFESTATION

Insect infestation of stored wheat may start from the remains of the preceding year's stored crop, from sweepings or bits of grain scattered about the bin floor, or from cracks and crevices in the wood which have become filled with dust and broken grain. In Oklahoma, some pests such as the Angoumois grain moth and the rice weevil may infest the wheat heads to a certain extent in the field and be brought in with the grain. The Angoumois grain moth breeds in corn cribs and waste grain in and around straw stacks, and in corn in the field. The rice weevil also breeds in similar places, especially in stored corn in cribs. One serious pest, the cadelle, burrows in the wood to pupate.

Feed such as bran, shorts, etc., may become infested and the insects migrate to the bin.

HOW INSECTS LIVE IN STORED WHEAT

An understanding of the biologies of stored wheat insects is neccessary for successful control or prevention. A brief account is therefore given of the life cycles of two common and injurious species, the Angoumois grain moth and the rice weevil.

The Angoumois grain moth breeds in wheat, other small grains, and corn. The moth, as is shown in Figs. 1a and 1e, is about the size of a wheat seed. It is light grayish brown in color, with a satiny luster, and the wings are marked lightly with spots and lines of black. The female moths lay an average of about 40 eggs each. The eggs are, of course, very small and difficult to see except by careful search with the aid of a magnifying glass. No food is neecssary for the moth, but access to minute droplets of water increases its egg-laying capacity.

In the summer the moths escaping from infested farm bins may lay eggs on the heads of ripening wheat in the field. These eggs hatch in about a week into tiny worms no

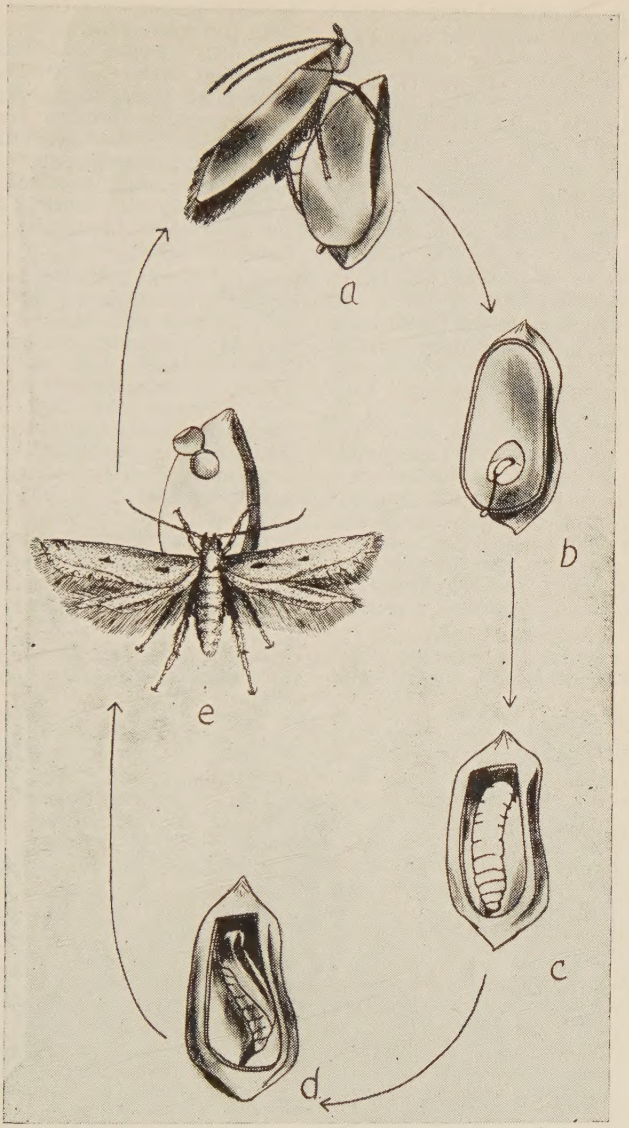

Figure 1. Life Cycle of the Angoumois Grain Moth

a. Moth on wheat kernel with egg. **b.** Wheat kernel cut open to show egg shell, entering tunnel made by worm, and cavity with small worm. **c.** Wheat kernel cut open to show cavity and full-grown worm. **d.** Same as **c** with pupal stage. **e.** Moth with wings spread, and exit hole in wheat kernel. (Redrawn from Fig. 2, U. S. Dept. Agri. Farmers Bul. 1811 by permission of the author, R. T. Cotton.)

thicker than a thread. These worms seek out the wheat kernels and tunnel into them, one worm to a kernel (Fig. 1b). The worm feeds on the inside of the seed, completely destroying the germ and hollowing out a cavity (Fig. 1c). When full grown, the worm is about ⅛ inch long, white, with a yellowish-brown head. It now stops feeding, sheds its skin for the last time, and becomes a pupa (Fig. 1d). This is of the shape shown in the figure and is reddish brown in color.

After remaining in the pupal stage for several days, the insect transforms into a moth which crawls out of the old pupal skin. It then forces its way out of the seed by pushing aside the thin membrane covering the cavity, this being made possible by the worm having previously eaten away all but the thin outer covering of the seed directly over the cavity. The characteristic circular holes in the kernel show that the moth has completed its life cycle and destroyed the seed (Fig. 1e).

From a few moths infesting wheat in the field, thousands may develop in later generations to increase the field infestation unless the wheat is promptly harvested and stored. It has been estimated that each female moth flying to the field in the spring may produce sufficient progeny to infest over 63 million kernels by October. After the wheat has been stored, development also continues in the kernels near the surface of the bin unless precautions are taken.

Uncut wheat standing in the field or shock, or stacked outside, cannot be protected from such a small insect as the Angoumois grain moth. The extent of field infestation of wheat in Oklahoma is not known, but it undoubtedly does occur because the insect has been found to infest corn in the field. While field infestation does not seriously damage the wheat, it is important because undoubtedly some bin infestations are brought about in this way and the situation may develop seriously if the moisture content of the stored wheat is above 13.5 percent.

Infestation of stored wheat in bins increases rapidly under temperature

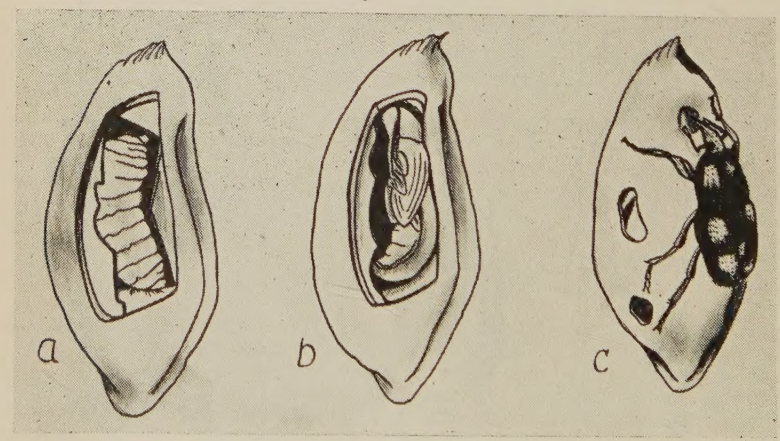

Figure 2. Life Cycle of the Rice Weevil

a. Wheat kernel cut open, showing weevil grub inside. **b.** Same as **a**, showing later stage (pupa) of the weevil. **c.** Rice weevil resting on injured wheat kernel. (Redrawn from Fig. 4, U. S. Dept. Agri. Farmers Bul. 1811 by permission of the author, R. T. Cotton.)

and moisture conditions which are favorable for the insect, as it may complete its life cycle in a little less than five weeks.

The rice or black weevil is a small, reddish brown insect, smaller than a kernel of wheat (Fig. 2c). On the back are four light reddish or yellowish spots which distinguish it from the granary weevil, which is of less importance but is known to occur in Oklahoma. At the end of the snout is a pair of jaws which are used to chew out a tiny hole in the seed. In this hole is deposited a tiny, white egg. In a few days the egg hatches into a soft, white grub which feeds on the inside of the seed, hollowing out a cavity. The grub when full grown is about ⅛ inch long, fleshy, and legless (Fig. 2a). It soon sheds its skin again and transforms into a soft, white pupa of the form shown in Fig. 2b. From this stage, in turn, the adult weevil develops. Weevils escape from the seed by chewing a hole in the side. The entire life cycle may be completed in 26 days at favorable temperature and moisture conditions. The adult weevil may live four or five months, and each female is capable of laying 300 to 400 eggs.

As in the case of the Angoumois grain moth, field infestation may develop from weevils flying from nearby infested bins, granaries, etc., and infestation of storage places may result from bringing in and storing the field-infested wheat or from residual infested wheat remaining in the bin.

PREVENTION

To prevent insect infestation of stored wheat:

Do not delay harvesting the wheat, and avoid leaving the shocks standing too long in the field. Prompt harvesting and storing in the bin reduce danger of infestation.

Clean all bins thoroughly before the grain is stored. Remove all waste grain from the floors of the bin.

Spray the bin thoroughly with a strong contact spray. A good fly spray may be used for this purpose. The following formulas are recommended:

Number 1.

Pyrethrum extract (20-1 concentration)	1 gallon
Odorless oil base	19 gallons

Number 2. (Illinois formula)

Dormant-tree spray oil	2 gallons
Lye	6 ounces
Water	18 gallons

A gallon of spray will cover approximately 50 square feet of bin surface.

The grain placed in the bin should be free from chaff, dirt, and any excess foreign material. The moisture content of the wheat should not exceed 13.5 percent.

FUMIGATION

Most of Oklahoma's wheat belt is included in the zone where stored wheat in farm bins should be frequently inspected and at least one fumigation given. With the exception of the panhandle counties, fumigation of all wheat immediately after storage is necessary to prevent damage by insects. It should be inspected within two weeks after this fumigation and the treatment repeated if living grain-infesting insects are found. In the southeastern and the extreme eastern counties of the state, inspections should be made every month throughout the year. In the rest of the state, inspections should be made monthly except during the winter. Fumigation should be repeated as often as necessary.

Wheat infested with insects will heat, and if inspection shows that the grain is heating, there is a possibility that insects are at work. Insect infestation will usually show up in the surface layer of the grain. A scoopful of grain carefully examined in good light will reveal insects if they are present. These

will be weevils, "bran bugs" (a general term applied to several species of beetles), and soft-bodied insect larvae which will later develop into beetles or moths. If there is any doubt as to whether the insects are injurious, send specimens to the Department of Entomology or the Extension Entomologist, Oklahoma A. and M. College, or call in the county agent.

An examination in 1938 of 621 samples of wheat taken from farm bins showed that 42 percent were infested. These samples were collected from 23 counties, and the county average infestation ranged from 19.2 percent to 64.9 percent. This survey shows that a very large percentage of farm bins in Oklahoma are infested and that it is extremely hazardous to store wheat for any length of time without fumigation.

FUMIGANTS RECOMMENDED

The Ethylene Dichloride-Carbon Tetrachloride 3-1 Mixture.—A mixture of ethylene dichloride and carbon tetrachloride is preferred to carbon disulphide because there is no fire or explosion hazard. The proportions recommended are 3 parts by volume of ethylene dichloride to 1 part of carbon tetrachloride The mixture can be purchased for about 75 cents a gallon or between 6½ and 7 cents a pound in 55-gallon drums.

Ethylene dichloride may be purchased at a cost of from 10 cents to 25 cents per pound, depending upon the quantity desired. It is a colorless liquid with an odor resembling chloroform. It evaporates slowly when exposed to air, forming a vapor that is heavier than air. It is noninjurious to seeds and is not dangerous to handle. When inhaled in concentrated form it has an anesthetic action, and care should be taken to avoid exposure for too long a time without using a gas mask. It burns very slowly, and when mixed in the above proportions with cabron tetrachloride does not burn at all.

Carbon tetrachloride sells for around 35 cents for a 1½-pound can down to 9 cents per pound in 60-pound drums. It is a liquid and evaporates at about the same rate as ethylene dichloride. It is noninflammable and in fact is sometimes used as a fire extinguisher. It has a low toxicity to insects. Avoid exposure to its fumes for any extended period without wearing a gas mask.

Because this 3-1 mixture is irritating to the eyes and throat, the person doing the fumigation should leave the bin as soon as possible after applying the liquid. Better still, apply the liquid to the grain from the outside. Before entering after fumigation, see that the bin has been ventilated thoroughly.

Carbon Disulphide—Carbon disulphide is the most common fumigant used to date in Oklahoma. It is highly toxic to insects, can be obtained in most communities, and is safe to use **provided strict precautions are used against fire and explosion hazards.** It is a heavy liquid with a powerful, disagreeable odor and sells for around 95 cents a gallon in 5-gallon lots to $9.00 for a 100-pound drum.

Carbon disulphide evaporates rapidly on exposure to air, forming a gas that is heavier than air. This gas sinks down through the grain, killing all insects it comes in contact with.

The liquid is inflammable and the gas when mixed with air forms a highly explosive mixture. When used, strict precautions must be taken against lights and sparks of all kinds such as frictional electricity, lighted pipes, cigars, cigarettes, lanterns, etc.

The fumes are poisonous to people if inhaled for an extended period. **Persons with heart trouble should not take any part in fumigation with this material.**

PREPARING BIN FOR FUMIGATION

Success in fumigation depends to a very large extent on a tight bin. The steel bin used on many Oklahoma farms for wheat storage is very satisfactory (Fig. 3). Wooden bins with large cracks or openings in the sides and bottoms cannot be

Figure 3. Easily Fumigated

A steel bin for farm grain storage such as this one can be easily fumigated if the roof and wall joints are tight and there are no leaks around doors.

fumigated with any hope of destroying insects unless they can be made tight (Fig. 4.) All cracks and openings should be covered with heavy building paper or with sheet metal. Sometimes the outside of the bin can be covered with paper or the bin can be lined before putting the grain in. In either case be sure to cover all openings through which the gas can escape.

The grain should be leveled off before fumigating and there should be at least 6 inches of side wall extending above the grain surface. This much space is needed to hold the gas for a sufficient length of time to allow it to penetrate into the grain mass.

If the grain is caked on top, this crust should be thoroughly broken up before applying the fumigant.

Fumigate only when temperature and wind conditions are favorable.— Best results with fumigation will be obtained when the temperature of the grain is above 60° F. However, during extremely hot weather, fumigation should be done during the cooler parts of the day. No fumigation should be attempted when there is a strong wind blowing; velocities above 15 miles per hour are unfavorable.

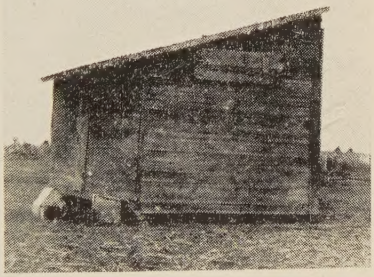

Figure 4. Difficult to Fumigate

It is impossible to fumigate wheat in such a building without first making extensive repairs.

AMOUNT OF FUMIGANT NEEDED

The ethylene dichloride-carbon tetrachloride mixture should be used at the rate of 5 to 8 gallons per 1,000 bushels of grain. The following table taken from Illinois Circular 512 gives the recommended dosages:

Bin Content	Amount of Mixture per 1,000 Bushels
Less than 500 bushels	8 gallons
500 to 1,500 bushels	6 gallons
1,500 to 3,000 bushels	5 gallons

Carbon disulphide should be used at the rate of 3 to 4 gallons per 1,000 bushels, larger bins requiring the smaller dosage per 1,000 bushels.

HOW TO APPLY FUMIGANTS

Either of the recommended fumigants may be applied directly to the grain by pouring from a container or watering pot, or by using a small spray pump. The latter method is considered the safest and most satisfactory, since the operator may remain on the outside of the bin when applying the fumigant. Avoid fumigating more than one bin if the fumigant is to be applied without a gas mask and by a method necessitating entering the bin and remaining inside during the application of the chemical.

To prevent loss of the vapor by surface evaporation, cover the grain with a canvas sheet or tarpaulin after applying the fumigant. The use of this cover is especially desirable when the grain is stored in bins that have large open spaces above the grain surface.